Appendix A

The Design and Development of the INEEL Oversight Program's Environmental Surveillance Program

History and Legislative Authority

In the late 1980s, at a time when facts about contamination from a half century of defense-related production were gradually coming to light, and DOE's credibility with state governments was consequently deteriorating, the U.S. Secretary of Energy proposed the concept of oversight roles for states hosting DOE facilities. Under this new proposal, the states would be given access to DOE facilities and information so that each state could conduct independent assessments of the potential environmental impacts resulting from DOE activities. The details of such arrangements were to be negotiated in agreements-in-principle (AIP), wherein DOE would obligate funds to ensure that states could carry out their oversight responsibilities.

On April 5, 1989, the Idaho Legislature enacted Senate Bill 1266, establishing a comprehensive oversight program for the INEEL, and on May 1, 1990, the state of Idaho and the DOE signed a five-year AIP entitled the Environmental Oversight and Monitoring Agreement (State of Idaho-DOE 1990). This agreement provided grant funding and other resources for establishing and supporting the state's INEEL OP, which was assigned the following responsibilities:

- Secure necessary data and information regarding DOE activities in Idaho;
- Scientifically evaluate this information in the context of total INEEL impacts on the public and environment; and
- Objectively report conclusions to the people of Idaho.

When the first AIP grant expired in 1995, the state of Idaho, DOE, and Naval Reactors negotiated a subsequent five-year AIP, which reinforced the fundamental elements of the program and built on the experience gained during the first five years of INEEL OP operations. INEEL OP, the DOE and NRF negotiated another subsequent five-year AIP in 2000.

By working cooperatively with DOE, INEEL OP has developed a successful program that includes a strategic monitoring network designed to supplement and verify DOE's environmental monitoring data, which allows the state of Idaho to provide independent oversight and surveillance of the environment and DOE activities at the INEEL.

Environmental Surveillance Program Network Design

The INEEL OP surveillance network selectively and independently collects samples of environmental media that could be contaminated by activities at the INEEL. Media sampled include air, surface water, groundwater, soil, and milk. The evolution of the INEEL OP monitoring network is summarized below.

Air Monitoring

The INEEL OP air monitoring network was created through a research and development agreement with DOE to conduct independent air monitoring activities on and around the INEEL.

By evaluating meteorological records, results from dispersion models, and the locations of actual or potential air emission sources at INEEL, the program identified potential offsite locations for six permanent air quality monitoring stations. Four of these sites were situated around the perimeter of the INEEL at Mud Lake, Monteview, Howe, and Atomic City. A fifth site was established on the INEEL at the Big Lost River Rest Area on U.S. Highway 20/26. Initially, these five sites were equipped with low-volume particulate samplers loaned to the INEEL OP by the U.S. Environmental Protection Agency (EPA). In 1992, these samplers were replaced with similar samplers, acquired from DOE's contractor surplus, which INEEL OP operated according to QA/QC and standard operating procedures. The sixth site, in Idaho Falls, was added to the network in the fall of 1992 to serve as a distant background monitoring location. Collectively, these six stations now serve as permanent monitoring stations in the air surveillance program.

In January of 1994, following DOE's decision to privatize its environmental surveillance program, the INEEL OP incorporated the four ISU Environmental Monitoring Program air-monitoring stations into its network. These stations, previously operated by ISU for DOE, included three locations on the INEEL--Sand Dunes Tower, Experimental Field Station, and Van Buren Avenue, and one offsite location at the Craters of the Moon National Monument. **Figure 2-1** in **Chapter 2** of this report provides the locations of these sites.

The network instrumentation of the ten air monitoring stations included samplers to collect airborne particulate matter smaller than ten micrometers in diameter (PM_{10}), atmospheric moisture, and gaseous radioiodine. However, after a two-year investigation comparing high-volume total suspended particulate (TSP) air samplers to the PM_{10} samplers, the TSP samplers were selected as a suitable replacement. Precipitation samplers operate at six of the ten monitoring stations to collect samples for radiological analyses.

External Radiation Monitoring

Each of the ten air monitoring stations described above is further equipped with an environmental dosimeter to measure time-integrated exposure to gamma radiation. For real-time measurement of ambient gamma radiation, the six original stations also employ high-pressurized ion chambers, from which data can be relayed via radio transmitter to the INEEL OP Idaho Falls office.

Expanding the radiation monitoring network in 1995, the INEEL OP applied historical meteorological data and dispersion modeling information to the process of selecting strategic locations for additional radiation monitoring stations. Now in place at Rover, near the eastern site boundary and southwest of Mud Lake, the Base of Howe Peak, the Main Gate, and near Big Southern Butte, these stations include both environmental dosimeters and high-pressurized ion chambers, and, with the exception of the Main Gate location, are powered by solar energy. The locations of these sites are shown on **Figure 2-2** in Chapter **2** of this report.

In 1999, the INEEL OP implemented a new type of environmental dosimeter to replace the thermoluminescent dosimeters previously used. Electret ion chambers (EIC) were deployed at the six original stations, the four stations formerly operated by ISU, and Rover, the Base of Howe Peak, the Main Gate, and near Big Southern Butte. In addition, EICs are deployed around the perimeter of the INEEL approximately every two miles and at NOAA mesonet towers throughout southeastern Idaho for a total of 91 locations. The locations of these sites are shown on **Figure 2-2** in **Chapter 2** of this report.

Terrestrial Media Monitoring

Deposition of radioactive material released from INEEL facilities to the air can cause accumulation and migration of radionuclides in the environment that may lead to human exposure or adverse environmental impacts. Terrestrial media that can be sampled to assess potential human and environmental exposure to deposited radioactive material includes, but is not limited to soil, vegetation, and milk.

The methodology used by the INEEL OP to identify terrestrial monitoring locations included an assessment of potential INEEL facility air emission characteristics, the evaluation of monitoring activities by other agencies, and careful consideration of INEEL OP objectives. Initially, soil monitoring locations were selected to further characterize the environment around the permanent air monitoring stations. Co-locating these two sampling activities supported comparisons of related background and long-term data trends. Periodically, an *in-situ* gamma spectrometer could be employed to determine background radiation information at co-located sampling locations.

Water Monitoring

Contamination of the Snake River Plain Aquifer underlying the INEEL is generally limited to areas near TAN, INTEC, TRA, CFA, and RWMC as shown in **Figure A-1**. In these areas, the concentration of one or more contaminants in the aquifer approaches or exceeds federal drinking water standards. Because the USGS has been monitoring water quality at the INEEL since 1949, many of the more than 300 wells presently used to monitor the Snake River Plain Aquifer in the vicinity of the INEEL are observation wells originally installed by the USGS.

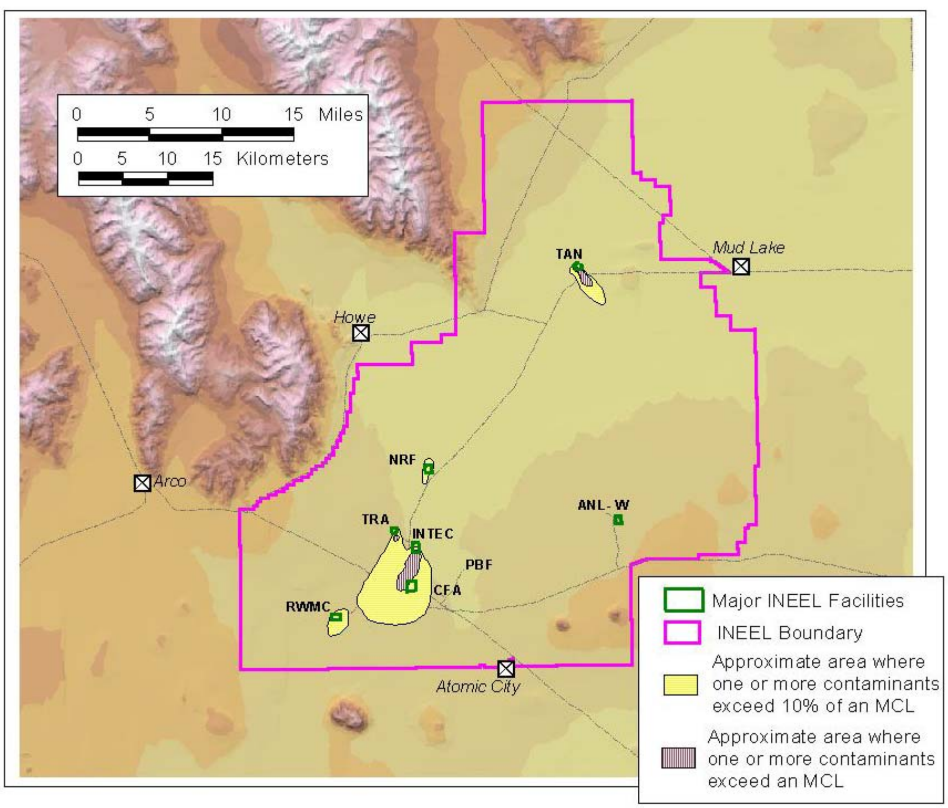

Figure A-1. Plume map showing areas of contamination of the Snake River Plain Aquifer at the INEEL

The INEEL OP water surveillance network combined two previously existing surveillance programs in 1993. The first, established by the ISU Environmental Monitoring Program in 1989, had previously conducted replicate sampling with DOE contractors and the USGS INEEL Project Office at 23 locations on and off the INEEL. The second, a cooperative program between the USGS and the Idaho Department of Water Resources (IDWR), performed sampling to determine the quality of water in the Snake River Plain Aquifer between the southern boundary of the INEEL and the Thousand Springs area along the Snake River near Hagerman. Merging these two surveillance programs, the INEEL OP assumed monitoring responsibilities from the ISU Environmental Monitoring Program, funded a position in IDWR to cover the expenses of collecting samples south of the INEEL, and implemented a three-year rotation sampling schedule for 55 sites. In addition, the INEEL OP water surveillance program initiated a new sampling program in 1999 to co-sample wastewater and groundwater collected by BBWI, ANL-W and NRF on the INEEL.

Over the past five years, the INEEL OP has expanded the number of monitoring locations originated by the surveillance programs and will continue to selectively add wells or springs to the network when one or more of the following criteria are met:

- Water from the location is used by the public;
- The location provides long-term community monitoring trends;
- Sampling from the location verifies and supplements monitoring by the INEEL contractor; and/or
- The location provides information at critical points along the groundwater pathway.

Currently, the INEEL OP collects water samples from 76 wells, 8 springs, and 3 surface water locations on and off the INEEL. With regard to the wastewater and groundwater sampling in 2002, 33 sites were sampled. Additional information regarding the locations, sampling schedules, and co-sampling organizations associated with the water monitoring program is provided in **Chapter 2** of this report.

Appendix B:

Glossary, Acronyms and Units

Glossary

A priori—Prior to measurement.

Accuracy—The degree of agreement of a measured value with the --true-- or expected value.

Activation products—Isotopes produced from the absorption by nuclei of neutrons in a nuclear reactor.

Activity—See radioactivity.

Alpha particle—Particle that is emitted from the nucleus of an atom, and contains two protons and two neutrons. Identical to the nucleus of a helium atom, without the electrons, an alpha particle is a form of radiation that can travel only a few millimeters in air, and be stopped by a piece of paper. Uranium-238, radium-226, and polonium-210 are all alpha emitters.

Atom—The smallest particle of an element that retains all the chemical and physical characteristics of that element. Every known atom consists of negatively charged electrons traveling around a nucleus. The nucleus, or core, of an atom contains protons, which are positively charged, and neutrons, which are uncharged.

Atomic weight—A number that identifies a specific isotope numerically equal to the number of protons and neutrons in the isotope. For example, the "90" in strontium-90 indicates a total of 90 protons and neutrons in the nucleus.

Background—Naturally occurring or constantly present radioactivity or chemical species in an environment. Cosmic rays and terrestrial radiation are two contributors to natural background.

Beta particle—A high-speed particle, identical to an electron, that is emitted from the nucleus of an atom. Beta radiation can be stopped by a thin sheet of metal about the thickness of foil. Strontium-90, cesium-137, and tritium are beta emitters.

Committed effective dose equivalent—The dose equivalent that will accumulate during the 50 years following the intake of a radionuclide.

Confidence interval—The range of values that may be expected to encompass the true value.

Cosmic radiation—Radiation which permeates all of space, from sources primarily outside our solar system. The radiation is in many forms, from high-speed, heavy particles to high-energy photons. Examples of cosmogenic radionuclides are carbon-14, tritium, and beryllium-7.

Cosmogenic radioactivity—Unstable atoms resulting from the interaction between cosmic radiation and atoms in the atmosphere. Examples of cosmogenic radionuclides include carbon-14, tritium, and beryllium-7.

Decay—The spontaneous transformation of one nuclide into a different nuclide or a different energy state of the same nuclide. For a radioactive nuclide, this transformation process results in the emission of nuclear radiation, such as alpha, beta, or gamma radiation.

Decay chain—The series of different nuclides into which a nuclide will change until a stable nuclide has been formed. During decay, nuclides may transform many times.

Disintegration—See decay.

Dose—A measurement of the quantity of energy absorbed per unit mass from any kind of ionizing radiation, also called absorbed dose. The traditional unit of absorbed dose is the rad.

Duplicate sample—A second sample randomly selected from a population of interest to assist in the evaluation of sample variation.

Effective dose equivalent—The summation of the weighting factor for tissue multiplied by the dose equivalent to tissue.

Electret ion chamber—An ionization chamber made up of polypropylene plastic which provides a nearly air-equivalent chamber. EICs are used to measure cumulative total of environmental gamma radiation exposure.

Exposure—A measure of ionization produced in air by x-rays or gamma rays. Unlike dose, exposure refers to the potential of receiving radiation. The traditional unit is the roentgen.

Fission—The splitting of nuclei by neutrons.

Gamma rays—Electromagnetic waves or photons emitted from the nucleus of an atom. Gamma radiation is very penetrating and is best attenuated by dense materials such as lead. Technetium-99, barium-137, and iodine-131 all produce gamma rays.

Gamma spectroscopy—Technique used to determine the distribution of radionuclides in a sample. Gamma spectroscopy identifies radionuclides since the gamma ray spectrum is characteristic for the radionuclides present in the sample.

Gas-flow proportional counting—Technique used to make gross alpha and gross beta screening measurements in a sample. Uses a gas-filled detector under certain conditions. Under these conditions, the number of counts in the detector is proportional to the number of ionization events taking place.

Gross alpha—Total alpha activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Gross beta—Total beta activity detected. Assumes all activity due to a single radionuclide with no species identified or decay corrected.

Half-life—The time it takes for one half of the atoms of a particular radionuclide to decay into another nuclear form. Measured half-lives vary from less than millionths of a second to billions of years.

Health physics—The interdisciplinary science and application of science for the radiation protection of humans and the environment. Health physics combines the elements of physics, biology, chemistry, statistics and electronic instrumentation to provide information that can be used to protect individuals from the effects of radiation.

High-pressure ionization chamber—A pressurized ion chamber is a sensitive photon detector capable of real-time measurements and provides real-time environmental gamma radiation exposure measurements.

In situ gamma spectroscopy—Gamma spectroscopic measurements performed *in situ*. The detector is placed directly over the area being analyzed. The advantage to this technique is that samples are not taken, which, in turn, minimizes the potential for cross-contamination and waste production.

Injection well—A well used for the disposal of wastewater.

Ionization—The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions (charged particles). High temperature, electrical discharge, nuclear radiation, and x-rays can cause ionization.

Ionizing radiation—Radiation with enough energy to remove tightly bound electrons from their orbits during an interaction with an atom, causing the atom to become charged or ionized.

Isotope—One of two or more atoms that have the same number of protons but a different number of neutrons in their nuclei. The atoms have nearly the same chemical properties, but their physical properties often differ. A radioactive isotope is called a radioisotope.

Liquid scintillation counting—A counting technique used to measure low-energy beta particles or alpha particles that involves the dissolution of the sample to be counted directly into a liquid scintillator.

Low-level radioactive waste—Waste that does not generally require shielding or heat removal, usually possessing small transuranic content.

Mean—Arithmetical average of a set of numbers.

Minimum detectable activity (MDA)—An *a priori* estimate of the activity that can be identified in a sample with 95% confidence under specified measurement conditions.

Minimum detectable concentration (MDC)—An *a priori* estimate of the activity concentration that can be identified with 95% confidence under a specified set of measurement conditions.

Non-ionizing radiation—Radiation lacking the energy to remove tightly bound electrons from their orbits around atoms. Examples are microwaves and visible light.

Nuclides—A general term used to denote the core, or nucleus, of all known atoms, both stable and unstable.

Neutrons—Neutral particles that are normally contained in the nucleus of all atoms, but may be removed by various interactions or processes like collision and fission.

Perched ground water –A layer of water-saturated sediment or rock separated from the underlying aquifer by unsaturated sediment or rock.

Perched water table—The upper surface of a body of perched water.

Percolation pond—Unlined wastewater pond where some of the water infiltrates into the ground.

pH—A measure of the acidity or alkalinity of a chemical solution; the negative log of the hydrogen ion concentration of a solution.

PM_{10}—All particulate matter in the ambient air with an aerodynamic diameter less than or equal to 10 micrometers. This size fraction is presumed to be respirable and is therefore of special interest.

Precision—A qualitative term used to describe the amount of random error in the measurement process, precision is a measure of the degree to which data generated from repeated measurements differ from one another.

Quality assurance—A management function that deals with setting policy and running an administrative system of management controls that cover planning, implementation, and review of data collection activities.

Quality control—Typically, all the scientific precautions, such as calibrations of equipment and duplicate sampling, that are needed to acquire data of known and adequate quality. Quality control is technical in nature and is implemented at the project level.

Radiation—Energy in transit in the form of high-speed particles and electromagnetic waves.

Radiation dose—The amount of energy deposited in biological tissues per weight of tissue.

Radioactive contamination—Radioactive material in an unwanted place.

Radioactive material—Any material that contains radioactive atoms.

Radioactivity—The spontaneous transformation of an unstable atom, which often results in the emission of radiation. This process is referred to as a transformation, a decay, or a disintegration of an atom.

Radioisotope—An unstable isotope or element that decays or disintegrates spontaneously, emitting radiation.

Radionuclide—A radioactive nuclide.

Sample variance—A measure of the dispersion of varieties observed in a sample expressed as a function of the squared deviations from the sample average.

Secondary maximum contaminant level—National drinking water standards regulating contaminants that primarily affect the aesthetic qualities of drinking water. At considerably higher concentrations, these contaminants may become health concerns.

Sigma (standard deviation)—A measure of the variability of a set of values; the square root of the variance.

Spent nuclear fuel—Nuclear fuel that has been removed from a reactor after being used to produce power.

Split sample—The type of replicate sample produced when a laboratory divides one sample into subsamples.

Thermoluminescent dosimeter—A monitoring device that can be worn by an individual or placed in the environment to measure total gamma radiation during a period of time.

Transuranic waste—Waste that contains isotopes above uranium in the periodic table of chemical elements in levels exceeding 100 nanocuries per gram. Typically, transuranic waste contains by-products of fuel assembly, weapons fabrication, and/or reprocessing operations.

Tritium (H-3)—A radioactive isotope of hydrogen that has two neutrons and one proton in the nucleus.

X rays—Electromagnetic waves or photons not emitted from the nucleus, but normally emitted by energy changes in electrons. These energy changes occur either in electron orbital shells that surround an atom or during the process of slowing energy down, such as in an x-ray machine.

Acronyms

AIP—Agreement-in-principle

ANL-W—Argonne National Laboratory- West

BBWI—Bechtel BWXT Idaho, LLC

CERCLA—Comprehensive Environmental Response, Compensation, and Liability Act, also known as Superfund

CFA—Central Facilities Area

DOE—U.S. Department of Energy

DQO—Data Quality Objective

EIC—Electret ion chamber

EPA—U.S. Environmental Protection Agency

ESER – Environmental Surveillance Education and Research Program

ESP—Environmental Surveillance Program

HTO – Tritium, tritiated water

HPIC—High-pressure ionization chamber

IBL—State of Idaho Department of Health and Welfare Bureau of Laboratories

ICP—Inductively Coupled Plasma Emission Spectroscopy

INTEC—Idaho Nuclear Technology and Engineering Center (renamed in 1998 from Idaho Chemical Processing Plant).

INEEL—Idaho National Engineering and Environmental Laboratory

INEEL OP—Idaho National Engineering and Environmental Laboratory Oversight Program

ISU EML—Idaho State University Environmental Monitoring Laboratory

LMITCO—Lockheed Martin Idaho Technologies Company

MAPEP—Mixed Analyte Performance Evaluation Program

MCL—maximum contaminant level

MDA—minimum detectable activity

MDC—minimum detectable concentration

NIST—National Institute of Standards and Technology

QATF—Environmental Radiation Quality Assurance Task Force of the Pacific Northwest

NOAA—National Oceanic and Atmospheric Administration

NRF—Naval Reactors Facility

PBF—Power Burst Facility

QA—Quality Assurance

RCRA—Resource Conservation and Recovery Act

ROD—Record of Decision

RWMC—Radioactive Waste Management Complex

SB—Shoshone-Bannock Tribes

SMCL—secondary maximum contaminant level

TAN—Test Area North

TLD—Thermoluminescent Dosimeter

TKN – Total Kjeldahl Nitrogen

TRA—Test Reactor Area

USGS—U.S. Geological Survey

VOC—Volatile Organic Compounds

Units

Curie (Ci)—A unit used to measure radioactivity. One curie equals that quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units: thousandths (mCi), millionths (uCi), billionths (nCi), or trillionths (pCi) of a curie. The International Standard (SI) unit that is comparative to the curie is the becquerel (Bq). There are 3.7E10 Bq in one curie.

Rad—Acronym for radiation absorbed dose. The rad is a unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed by some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The unit rad can be used for any type of radiation, but it does not describe the biological effects from different radiations. The International Standard (SI) unit that is comparative to the rad is the gray (Gy). There are 100 rads in one gray.

Rem—Acronym for roentgen equivalent in man. The rem is a unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or mrem. To determine equivalent dose (rem), the absorbed dose (rad) is multiplied by a quality factor (Q) that is unique to the type of incident radiation. The International Standard (SI) unit that is comparative to the rem is the sievert (Sv). There are 100 rem in one sievert.

Roentgen (R)—The roentgen is a unit used to measure a quantity called exposure, but only when used to describe an amount of gamma and X-rays in air. One roentgen is equal to depositing to 2.58E-4 coulombs of energy per kg of dry air, and is a measure of the ionizations of the molecules in a mass of air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma and x-rays.

SI Prefixes—Many units are broken down into smaller units or expressed as multiples using standard metric prefixes. As examples, a kilobecquerel (kBq) is 1000 becquerels, a millirad (mrad) is a thousandth of a rad, a microrem (urem) is a millionth of a rem, a nanogram (ng) is a billionth of a gram, and a picocurie (pCi) is a trillionth of a curie.